EXPERT INTERVIEW: HOW TO TEACH PROGRAMMING AND CODING REMOTELY

About Dr. Danahy

Dr. Ethan Danahy is a Research Assistant Professor at the Center for Engineering Education and Outreach (CEEO) at Tufts University in Boston, MA. He researches the design, implementation, and evaluation of different educational technologies, including remote learning, and how these tools can improve interactive pedagogies for learners in K-12 through university. With a particular focus on engaging students in STEAM subjects, Ethan aims to enhance creativity and innovation, support better documentation, and encourage collaborative learning.

We had the privilege this week of taking some time out of Dr. Ethan Danahy's very busy schedule to talk to him about remote learning tools and how to teach programming and coding remotely. He provided his expert advice and some great resources that will help educators around the world teach their students STEAM lessons while they learn from home.

Arduino Education: How long have you been teaching remotely?
Ethan Danahy: Most of my teaching is done in person, and I very much value the in-person environment where I can see and interact with my students. I've structured my class around those philosophies: I try not to just do pure lecture, but I introduce concepts and then have the students engage with those concepts themselves. In order to support this shift away from lecture, I "flipped my classroom" and created lots of short videos for the course's core concepts that students could watch before class.

I now have a collection of online videos, and several years ago I taught a pure online version of my robotics course (shipping the students the physical kits and teaching remotely). Of course, the challenge then was how do I still maintain the hands-on aspect of the course, as well as the personal connections within the remote environment?

With the COVID-19 pandemic and transition to virtual learning, I (like all teachers) had to immediately transition from an in-person class to a 100% remote online learning experience. The one thing I really focused on was how to make sure my students feel like they're getting a personalized human-contact high-touch experience, even when they're by themselves perhaps thousands of miles away.

AE: What are the tools you use to teach remotely?
ED: I originally used YouTube to host my videos as I could see from the back-end statistics when students were watching videos, how long they watched for, when their attention was dropping, etc. This allowed me to address issues I detected and reinforce certain concepts as needed.

Now I host videos on *Canvas*, a Learning Management System (LMS) that Tufts uses. It has a wide range of analytics that provides very detailed information (and on a per-student basis, since they are logged into the system) for helping you as an educator understand your students' progress.

But for teaching remotely, engaging the students in conversation and in working through project-based learning, I've been using a range of other tools such as Zoom, and other conferencing platforms. This has been great in that I have the opportunity to see and hear my students, and give some "partial" face-to-face human contact.

For learning in general, what's really important to me is tapping into what my students are thinking. I'm very interested in exploring new tools and technologies that can capture and visualize those ideas.

We had a research project at Tufts University several years ago that developed a piece of software that has since become a startup called Visual Classrooms. *Visual Classrooms* provide an interactive digital space for your classroom that allows educators to ask their students questions, have them respond dynamically with these Post-it-like note responses, see what other students are saying and respond, tag, and analyze responses, and even rearrange and group ideas together. It provides a really good way for comparing and contrasting different students' ideas.

We're also exploring other tools that can engage students in different ways. Industry uses a lot of software, tools, and platforms that connect remote workers together in

order to collaborate effectively. So in education, we're tapping into those to try and replicate the effectiveness of what's happening at the corporate level, and expose our students (who will become future engineers and employees of those companies) to the tools and become familiar with the industry standards.

AE: How do you assess students learning from home?
ED: Assessment is a big topic in education, of course, and is tricky even when you're teaching in person. There are no easy answers here.

When I'm teaching in person, my assessment techniques fall into a range of strategies. Because my students engage in a lot of open-ended, project-based learning, judging diverse solutions makes assessing each creation more difficult. When everyone is producing something slightly different, how do you give numerical grades, how do you give appropriate feedback, how do you evaluate what they're doing in a way that is constructive to the students and is fair and valid across the class?

I use traditional assessments, such as timed written exams. The transition to online has made that more difficult, of course. As a result, we 've been talking about shifting the traditional exam model, not just asking true/false and yes/no type questions, but instead changing the questions to more personalized formats. This means students aren't able to copy somebody else's answers, but have to do real deep thinking on their own - and as an educator you get more insight into their understanding.

AE: Are you able to still do group projects when teaching remotely?
ED: Teaching remotely means the idea of group work has introduced new challenges as well. I'm still experimenting myself and learning new strategies for how we can do effective group projects and remote collaboration around hands-on learning when we are all separate.

In the past I've experimented with this, when I did my online robotics course, through a collaborative "robotic puppet show" assignment. Even though students were remotely located from each other, each student had their own kit and was building their own robot and they had to come together in order to work together around a final puppet show creation. To achieve this, students used collaboration tools for remote learning: Google Docs for writing scripts, cloud file storage for sharing resources and editing things together, etc.

Group work requires teams, and teamwork requires both grouping students together and giving them the skills to effectively collaborate. The strategies of effective team formation in education is a complex one and does not have a universally applicable solution because, and this is something I believe strongly, it is so dependent on a lot of individual variables specific to the content of a particular classroom, such as background of the students, skills and comfort of the individuals, culture that the

classroom already has, age and maturity of the students, etc. And the factors are increased when teaching remotely.

AE: What are your three top tips for teaching remotely?
ED: As educators transitioning to remote teaching, we need to reflect on the things that we value most from the in-person experience and think about strategies that ensure those principles are maintained online. For me, my values are around group discussions, being responsive in real-time to individual student needs, and including hands-on project-based learning in my teaching.

That personalized experience is so important, and I can implement that in person, even with a fairly large class. It's not really possibly online, but there are ways to use technology to get similar experiences; for instance the Zoom "breakout room" allows students to engage in small group discussions and the educator can engage with these small groups, interject new ideas, direct the conversation, or respond to what the students are thinking and experiencing.

Another key feature of the in-person experience that is often lost during remote teaching is student engagement. How can we keep students excited about the learning process? There is now even more emphasis on educators to create engaging, exciting assignments. We need more assignments that allow the students to engage in and explore topics more authentically.

And the third strategy for supporting our remote learners is super open communication between student and educator. Making sure that the students realize they're part of an active learning community by having regular and clear communication channels is extremely important. Ensuring that your students can communicate with you means using a range of technologies and methods, iteratively finding ways that work best for you and your students. Tools like *Piazza*, which allow group crowdsourcing of questions and answers within a class, is a way that can support that learning community on-demand 24/7.

AE: What are the best ways of getting students hands-on while they're learning at home?
ED: I feel the biggest goal is to maintain project-based learning even when we're teaching remotely. Just because learning has transitioned online, we don't want to fall back to an instructional model based on lecturing followed by a question-and-answer worksheet assignment. But how do we still maintain project based learning? Hands-on learning is a subset of project-based learning, and is certainly more difficult now we're remote. So, ensuring that even if we can't necessarily do hands-on learning, we are still doing more involved project-based learning that requires students to think, innovate, create (perhaps in a digital space), and apply their knowledge.

I believe though that in these remote learning environments, we need to have some kind of tangible construction materials available in order for students to physically build. These materials can range from ones that might be available in their homes, or it might require an investment in other resources that we need to have the students purchase or have shipped to them for their use remotely, like the *Arduino Student Kit*, for example. To scale, and given the many budgetary constraints across the educational field, we need to consider any and all tools that are either readily available or inexpensive. I personally love materials that provide open-ended design projects for the students and that can be reused across multiple activities.

We also need to consider how we can help students problem solve on their own. If a student has a question like, "how do I attach these two things together?", "why isn't this working?", "how does this code work?", or "what's wrong with my code?" we need to know how we're going to answer that with remote learning tools. Video tutorials, great quality documentation, and thinking about how students can leverage group work can all help here.

AE: What challenges do you see for remote learning?
ED: The things that I value most about my in-person teaching are some of the biggest pain points when transitioning to remote learning: maintaining the personal connection between educators and students and students and their peers, keeping students engaged, and providing adequate real-time support for students when they get stuck.

I want to design assignments that sufficiently challenge students, but that don't overwhelm and make them feel too far in the deep end.

AE: Have you found any aspects of remote learning that have been beneficial for your students or for your teaching?
ED: I'm excited by the inherent nature of the tools we are using, in that students are now providing a lot of digital responses to questions. This has now allowed a democratization across the classroom in terms of student voices being heard; when the responses are digital and accessible to everyone, it allows students equal access to their peers' thinking without one voice dominating the conversation. The flip side, however, is that students are sometimes nervous to capture their thinking in a digitally persistent form.

There are now digital tools out there that allow students' thinking (or projects, or work) to be captured, represented, and made that available to others. There is a real benefit to learning that comes from interacting as a group and not progressing just as an individual; so I encourage use of digital tools that work to reveal student thinking within the learning community as opposed to locking everything down as each student works independently and in secrecy.

I predict that even once we return back to "normal" in-person teaching, educators are going to be bringing many of the tools we leveraged during remote instruction back into our physical classrooms to digitally support group discussions through the simultaneous digital capturing of classwide thoughts.

AE: Thanks, Ethan - this has been so insightful. Is there anything else you'd like to mention?
ED: The focus is often, and I certainly put my own attention there as well, on the educators tasked with this transition to remote learning. But we need to acknowledge the roles other players in the educational ecosystem play, from students to parents to administration.

This new model of education is new to most of us, and we need to recognize that the ultimate solution to remote learning isn't trying to copy or duplicate the in-person experience exactly, but rather try and replicate things we value from the in-person while also enhancing and shifting the experience based on some of the advantages of the new tools and technologies available.

School leadership, who has also been thrust into this educational experiment, has an important role in carefully balancing the shift between teacher choice and institutional oversight. Teachers know their classrooms, their students, and their content and need to be supported in making the right decisions (in terms of style of content, frequency, appropriate interactions, use of tools and technologies, etc) that's best for their particular students and learning goals. Too many directives from the outside (requirements on format, instructional time, style of interactions, etc.) will constrain teachers. But too little involvement means they will feel unsupported, and I know teachers are looking for guidelines, new ideas and inspiration, connections within the educational community, training and professional development with new tools and technologies (and pedagogies) to support their teaching, etc.

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